WE CLAIM:

1. A method for synthesizing a cyclic polymer via a ring insertion polymerization reaction, comprising combining, to provide a reaction mixture, a cyclic olefin monomer with a catalytically effective amount of a transition metal alkylidene complex containing a cyclic group of known size, whereby: the cyclic olefin monomer successively inserts into the cyclic group to increase the size thereof in a stepwise manner without detachment of any linear species from the complex; and following completion of polymerization on the transition metal alkylidene complex, the cyclic polymer is released from the complex by an intramolecular chain transfer reaction.

2. The method of claim 1, wherein the reaction is carried out in the liquid phase.

3. The method of claim 2, wherein a solvent is added to the reaction mixture.

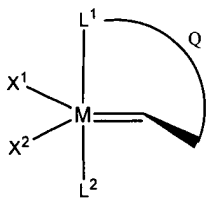
4. The method of claim 2, wherein the cyclic olefin monomer serves as a solvent and no additional solvent is added to the reaction mixture.

5. The method of claim 2, further including precipitating the cyclic polymer by addition of a precipitating solvent to the reaction mixture.

6. The method of claim 5, further including isolating the precipitated polymer by filtration.

7. The method of claim 1, wherein the transition metal alkylidene complex has the structure of formula (I)

(I)



wherein:

M is a Group 8 transition metal;

L^1 and L^2 are neutral electron donor ligands;

X^1 and X^2 are anionic ligands, and may be taken together to form a single bidentate ligand; and

Q is a linkage selected from optionally substituted and/or heteroatom-containing C_1-C_{20} alkylene, C_2-C_{20} alkenylene, C_2-C_{20} alkynylene, C_5-C_{24} arylene, C_6-C_{24} alkarylene, and C_6-C_{24} aralkylene linkages,

wherein L^1 and L^2 can be taken together with each other or with X^1 or X^2 to form a cyclic group, and further wherein any one of X^1, X^2, L^1 and L^2, R^1, and R^2 can be attached to a solid support.

8. The method of claim 7, wherein M is Ru or Os.

9. The method of claim 8, wherein M is Ru.

10. The method of claim 9, wherein:

L^1 is a carbene ligand;

L^2 is selected from phosphine, sulfonated phosphine, phosphite, phosphinite, phosphonite, arsine, stibine, ether, amine, amide, imine, sulfoxide, carboxyl, nitrosyl, pyridine, substituted pyridine, imidazole, substituted imidazole, pyrazine, and thioether; and

X^1 and X^2 are independently selected from hydrogen, halide, C_1-C_{20} alkyl, C_5-C_{20} aryl, C_1-C_{20} alkoxy, C_5-C_{20} aryloxy, C_2-C_{20} alkoxycarbonyl, C_6-C_{20} aryloxycarbonyl, C_2-C_{20} acyl, C_2-C_{20} acyloxy, C_1-C_{20} alkylsulfonato, C_5-C_{20} arylsulfonato, C_1-C_{20} alkylsulfanyl, C_5-C_{20} arylsulfanyl, C_1-C_{20} alkylsulfinyl, or C_5-C_{20} arylsulfinyl, any of which, with the exception of hydrogen and halide, are optionally further substituted with one or more groups selected from halide, C_1-C_6 alkyl, C_1-C_6 alkoxy, and phenyl; and

Q is C_2-C_{18} alkylene or C_2-C_{18} alkenylene.

11. The method of claim 10, wherein:

L^1 is an N-heterocyclic carbene ligand;

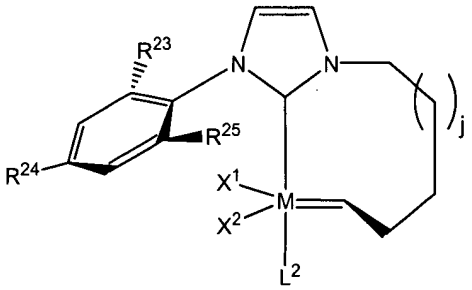
L^2 is a phosphine ligand of the formula $PR^1R^2R^3$, where R^1, R^2, and R^3 are each independently aryl or C_1-C_{10} alkyl;

X^1 and X^2 are independently selected from halide, CF_3CO_2, CH_3CO_2, CFH_2CO_2, $(CH_3)_3CO$, $(CF_3)_2(CH_3)CO$, $(CF_3)(CH_3)_2CO$, PhO, MeO, EtO, tosylate, mesylate, and trifluoromethanesulfonate; and

Q is C_2-C_{12} alkylene or C_2-C_{13} alkenylene.

12. The method of claim 11, wherein the transition metal alkylidene complex has the structure of formula (IX)

(IX)

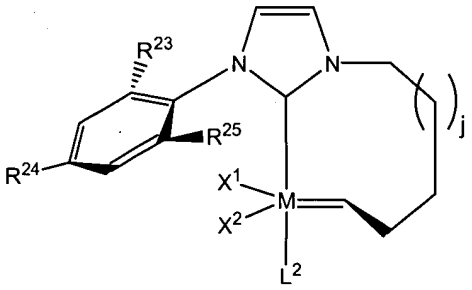


in which j is an integer in the range of 1 to 6 inclusive, X^1 and X^2 are halide, and R^{23}, R^{24}, and R^{25} are lower alkyl.

13. The method of claim 12, wherein j is 3, X^1 and X^2 are chloride, and R^{23}, R^{24}, and R^{25} are methyl.

14. A transition metal alkylidene complex having the structure of formula (IX)

(IX)



wherein:

j is an integer in the range of 1 to 6 inclusive;

M is a Group 8 transition metal;

L^2 is a neutral electron donor ligand, and X^1 and X^2 are anionic ligands, wherein any two of L^2, X^1 and X^2 can be taken together to form a single bidentate ligand; and

R^{23}, R^{24}, and R^{25} are lower alkyl.

15. A cyclic hydrocarbon polymer substantially free of linear contaminants and having a number average molecular weight of at least about 150 kD.

16. The polymer of claim 15, having a number average molecular weight of at least about 500 kD.

17. The polymer of claim 16, having a number average molecular weight of at least about 1000 kD.

18. The polymer of claim 17, having a number average molecular weight of at least about 1200 kD.

19. The polymer of claim 15, comprising a cyclic polyoctenamer.

20. The polymer of claim 15, comprising cyclic polyethylene.

21. The polymer of claim 15, comprising cyclic polybutadiene.

22. A polymer blend comprising the polymer of claim 15 and at least one second polymer.